DOCUMENT RESUME

ED 028 411 AL 001 578

By-Spolsky, Bernard

What Does it Mean to Know a Language, Or How Do You Get Someone to Perform His Competence?

Pub Date Nov 68

Note-23p.; Paper prepared for the second conference on Problems in Foreign Language Testing, University of Southern California, November 7-9, 1968.

EDRS Price MF-$0.25 HC-$1.25

Descriptors-Cloze Procedure, Communication Problems, Interference (Language Learning), Language Tests, *Linguistic Competence, *Linguistic Performance, Linguistic Theory, *Redundancy, *Second Language Learning, *Verbal Communication

Fries' definition of knowing a language rejects the layman's notion that the criterion is knowing a certain number of words. It involves, rather, knowing a set of items--sound segments, sentence patterns, lexical items--which must be made a matter of automatic habit. Various approaches to testing someone's use of a language have failed to take into account two vital truths about language: it is redundant, and it is creative. Redundancy, which may seem wasteful of effort, is of great use, as it reduces the possibility of error and permits communication where there is some interference in the communication channel (i.e., noise). Implications are that knowing a language involves the ability to understand a distorted message, and that theoretical questions may be raised about the value of deciding a person knows a language because he knows certain items in the language. Other implications are that one may learn a language just as well by listening as by speaking, and that we can find out about "knowledge of a language" equally well when we test passive and active skills, because the same linguistic competence, the same knowledge of rules, underlies both kinds of performance. One approach to test ability in a second language may be to add noise, or mask portions of text. (AMM)

ED028411

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

What does it mean to know a language, or how do you get someone to perform his competence?

Bernard Spolsky

The University of New Mexico

This paper has been prepared for presentation at the second conference on Problems in Foreign Language Testing, to be held at the University of Southern California, November 7-9, 1968.

AL 001 578

If we wish to speak of the process of second language acquisition, we must first consider the end result and consider the notion "knowing a language." How do we know that someone has learned a language? What does it mean when we say that someone knows a language?

Consider first the definition offered by Charles Fries:

> A person has 'learned' a language when he has thus first, within a limited vocabulary mastered the sound system (that is, when he can understand the stream of speech and achieve an understandable production of it) and has, second, made the structural devices (that is, the basic arrangements of utterances) matters of automatic habit.[1]

Fries arrives at this position after first showing the inadequacy of the notion that knowing a language means knowing its vocabulary. He points out that even a native speaker's knowledge of the words in his language is limited by his experience; we never finish learning all the words and their many meanings, as even a few minutes' study of a dictionary will prove. On the other hand, he claims, we early finish with the business of mastering the sound system - a child of four can recognize all the sounds of his language and produce recognizable variants of them - and of mastering "the fundamental matters of word-order and the patterns of form" - by the time he goes to school, a child has learned the basic grammar of his language.

It is natural, then, that we tend to believe that second language learning is a matter of doing in another language what we are conscious of doing in our own, namely, learning words, rather than being what we did unconsciously as young children when we mastered the phonology and grammar.

Fries argues then that vocabulary need not be stressed in initial phases of language learning:

> Accuracy of sound, of rhythm, of intonation, of structural forms, and of arrangement, within a limited range of expression, must come first and become automatic habit before the student is ready to devote his chief attention to expanding his vocabulary. [2]

It is interesting to see what happens when Fries' definition of knowing a language is translated into practical terms by preparing a test to see whether a student knows a language. Let us assume first that knowing a language consisted only in knowing (that is, in being able to recognize definitions or synonyms of) the words of the language. Obviously, we wouldn't test the student with every word in the dictionary before we decided whether he came up to the criterion. We would make use of some appropriate statistical technique to select a representative sample of words, find out what percentage our student knows, and compare his performance with that of a native speaker of the language. Obviously, the process is not simple, but it is feasible, for we are dealing with a more or less finite

number of items (the words of a language) from which we can choose a more or less representative sample; we need have little hesitation in generalizing our results.[3]

Can this same degree of finiteness be found if we move from the area of vocabulary that Fries rejects as irrelevant to the areas he names, the 'sound system' and the 'structural devices'? The answer is yes, if we consider that each of these systems is a matter of listing items and listing patterns for arrangement. For the former, one would list the segmental phonemes, the suprasegmentals, and the possible combinations. The list of phonemes would be quite small, no more than sixty or so items, so that it would be quite easy to test each item, although when one started to worry about all the possible combinations, the list would get much larger and sampling would be necessary.[4] Similarly, if one follows Fries, the 'structural devices' are equally straightforward, a matter of a list of items and possible arrangements. He points out that English uses three structural devices: word order, inflection, and function words. It is possible, he says, to select from these a minimum set that will provide for the production of "one pattern for each of the situations in which the language is actually being used"[5] and a larger set for recognition, chosen on the basis of frequency of occurence in the speech of native speakers of the language. It is possible to list the items in these sets[6] and to use the list as a universe

from which we can draw a representative sample to decide whether a student has learned the language or not.[7]

Fries thus rejects the layman's notion that knowing a certain number of words in a language is the criterion for knowing that language, but maintains a related notion, that knowing a language involves knowing a set of items. He speaks of lists of individual elements (sound segments, sentence patterns, lexical items) to be mastered, and says that to learn a language, one must make each of these items a matter of automatic habit.

While it may be true that the layman's idea of <u>learning</u> a language is learning words, his criterion for <u>knowing</u> a language is usually expressed quite differently. When he judges his own or anyone else's control of a language, he is much more likely to make a functional statement: "I know enough French to read a newspaper," "He can't speak enough English to ask the time of day." Statements such as these refer to language use and not to grammar or phonology. The question then arises, how does one go about deciding when someone knows "enough" to carry out a specified function. One approach is of course to give him a language-using task to perform. If we want to know whether someone knows enough English to understand a lecture on thermodynamics, we can have him listen to such a lecture and then check his comprehension.[8] Another approach is to attempt to characterize in linguistic terms the knowledge of the language required to function in this way, that is to say, to describe the

linguistic knowledge which correlates with the functional ability.[9] If Fries is working in a correct framework, the procedure is relatively clear. We say that underlying any functional use is a number of discrete elements; the functional use is thus an integrated system. Functioning in a language then involves, among other things, mastery of the sound system. Mastery of the sound system includes knowing a given number of phonemes. A test that finds out whether a subject knows these phonemes gives evidence of part of his knowledge of the language. By adding the results of similar tests of grammatical structures and of vocabulary, we can finish up with a clear picture of his knowledge. The results of batteries of tests like these can then be compared with his actual functioning in the language.

There are many reasons why this approach has not proved successful;[10] one of the fundamental reasons is that it fails to take into account two vital truths about language, the fact that language is redundant, and the fact that it is creative.

Redundancy is a concept developed as part of the statistical theory of communication.[11] In this theory, a message carries information to the extent that it effects a reduction in uncertainty by eliminating certain probabilities. The greater the reduction, the greater the information. Thus, the result of throwing a dice (with six possibilities) carries greater information than the result of the toss of a coin (with only two possibilities). Or consider a more linguistic

example. I ask someone to write down his first name. When I see him write the letter "P", the uncertainty has been reduced by a large amount, for he has excluded all names that begin with any other letter. When he adds "a", uncertainty is further reduced as names like "Peter" and "Phillip" are ruled out. Adding the letter "u" makes it pretty easy to guess the final answer; "l" makes me almost positive, and his lifting the pen merely serves to confirm my guess. From this example, we can see again the way in which different parts of the message carry varying amounts of information. The letter "P" gave the most information, for it cut down the possibilities from the whole set of possible men's names to the set of names beginning with "P", a reduction, let us say, to 1/26 of the original.[12] The letter "a" reduced the possibilities to an even smaller set, but by a smaller proportion. This is because of the fact that in English only thirteen letters can follow the letter "p." There just aren't any words in English that start with the letter "p" and have as their next letter "b,c,d,g,j,k,m,p,q,v,w,x," or "z", so that the information value of "a" in this case is 1/13 rather than 1/26. As more letters are added, the amount information conveyed by each letter becomes less, until certainty is reached. Now, the interesting thing here is the relation between the amount of information and our ability to guess. Our guessing, which gets easier as we go on (as the remaining elements contain less information) has depended on the knowledge that we have of the probabilities of occurrence of the

various elements in the order they appear. It is our knowledge of the rules of English that permits us to rule out 50% of the possibilities for the second letter of the word. If English were not restricted in this way, the second letter would convey as much information as the first. The probability relations between the two letters, effected by the rules of English spelling and phonotactics, reduced the amount of information carried by the second letter. In a language without such restrictions, more information could be conveyed using fewer units. In natural languages, more units are used than are theoretically necessary; that is to say, natural languages are redundant.

Redundancy may seem wasteful of effort, but it is in fact of great use, for it reduces the possibility of error and permits communication where there is some interference in the communicating channel. The technical term for this interference is noise. Consider an example. We might wish to set up a system of bells to communicate with a secretary in the next office. Say we set up a code as follows:

one ring: "Come in for dictation."

two rings: "Send the visitor in."

three rings: "Come and show the visitor out."

four rings: "Don't disturb me."

In such a code, each message has one and only one interpretation, and the difference between each is minimal. Any accident - the telephone ringing at the same time, touching the bell accidentally, pressing the bell once too often, losing

count while pressing - will lead to misunderstanding and an annoyed secretary. The system then is efficient, but liable to error and open to interference. One way of reducing the chance of error or interference is to add redundancy; for instance, to say that the signal will be repeated after ten seconds, or to add a system of lights or flags confirming the message. In a redundant system, I can be more sure of the message getting through.

When one considers all the interferences that occur when natural language is used for communication, it is clear that only a redundant system would work. The redundancy of natural language can be illustrated in many ways. It is possible to understand messages with many words omitted; not just in telegrams

HAVING WONDERFUL TIME SEND MORE MONEY

which are unambiguously reconstructable, but when words have been left out in a purely statistical way:

when, for _____, every third _____ is left _____, it is _____possible to _____. When it is every sixth _____, it is really so simple _____ you can read it as _____ as if all are there. But _____ second _____ is _____ difficult.

In much the same way, it is possible to guess at words with letters left out. One becomes most conscious of what is involved when one is doing a crossword puzzle. Note the three types of information that one is given to help guess: the number of letters in the word, the meaning of the word, and,

as one goes on, certain of the letters. But note also the help one gets from knowing the rules of English spelling; as soon as a "q" appears, one is almost completely certain as to the next letter. Another clear example is when there is noise interfering with the understanding of a spoken message. Talking on a telephone, or using radio-telephony, or conversing at a cocktail party are clear cases of understanding messages even though only a portion of the original signal gets through. The important point to note is that in all these examples, there has been no linguistic principle involved in the omissions, simply a random interference. That is to say, messages in normal language can be understood even though a good proportion of them is omitted or masked; or in other words, every message contains many elements (defined statistically rather than linguistically) that can be omitted without breaking down communication.

But if we give these distorted or incomplete messages to someone who doesn't know the language well, we find that there is a considerable difference. He just cannot function under these conditions: he needs the full normal redundancy, and at times even that is not enough. Consider for example how when we speak to someone whose native language is different, we speak more slowly, more clearly, with added gesture and frequent repetition. Or take some experimental evidence. In some studies we made of the possibility of using the redundancy principle in testing[13] we compared the performance of native speakers of English and non-natives (including some with very high competence) in writing down English sentences that were read to them on a tape to which varying amounts of noise had

been added. We were not surprised to find that the more noise we added, the more mistakes were made; nor were we surprised to find that some non-natives did as well or better than natives when there was no added noise; but what was important was the clear distinction that one found between natives and non-natives as soon as any noise was added. This is to be explained by the non-native's inability to function with reduced redundancy, evidence that he cannot supply from his knowledge of the language the experience on which to base his guesses as to what is missing. In other words, the key thing missing is the richness of knowledge of probabilities - on all levels, phonological, grammatical, lexical, and semantic - in the language. It is possible to factor out each of these elements, and explore the exact nature of the language learner's mastery of each item, but in the broad matter of functioning in a language, all combine to form an integrated whole, the exact contribution of each part being indefinable. In a non-redundant language system, the absence of any single element would reduce communication by a specific amount; language, however, permits communication to continue even when a large portion of the signal, and a random portion at that, is masked or missing.

Two implications follow. The first is that knowing a language involves the ability to understand a distorted message, to accept a message with reduced redundancy. A model of understanding speech must then include the ability to make valid guesses about a certain percentage of omitted elements. From this follows the usefulness of such language testing

techniques as the noise test referred to and the close procedure. The second implication is to raise some serious theoretical (but not necessarily practical) question about the value of deciding a person knows a language because he knows certain items in the language. The principle of redundancy suggests that it will not be possible to demonstrate that any given language item is essential to successful communication, nor to establish the functional load of any given item in communication. Consider the ease with which speakers of different dialects, dialects even with different number of phonemes, manage to converse, or the ways in which speakers constantly handle their forgetting a specific word. All of this suggests then that while a testing of specific linguistic items is likely to be valuable in the control of instruction, the assessment of proficiency in a language must rather be based on functioning in a much more linguistically complex situation than is provided by the one element test.

Knowing a language involves knowing the items that make up the language, but it also involves being able to supply these items when they are missing, or being able to do without them. Even were we able to list all the items, we could not show that to know a language you need know any one of them.

The creative aspect of language was for some time lost sight of in the behavioristic models that dominated linguistics in the first half of the twentieth century. Chomsky (1964) points out the two conflicting views of the essential nature of language that had been held in the nineteenth century. On

the one hand was the Humboldtian view: the essence of language is its Form, a constant and unvarying factor underlying each new linguistic act.

> It is by having developed an internal representation of this form that each individual is capable of understanding the language and using it in a way that is intelligible to his fellow speakers.[14]

Contrasted with this is the view expressed by Whitney: "Language in the concrete sense ... (is) ... the sum of words and phrases by which any man expresses his thought...."[15] Saussure, under Whitney's influence also regarded langue as an inventory of elements: it was perhaps for this reason that he relegated the sentence to parole.

> De Saussure's personal bent was probably to understate the creative act and to emphasize the mechanical process, just because the former, at first sight, seems to be the very essence of speech.[16]

It was the understatement of the creative aspect, then, that marked linguistics until Chomsky restated the Humboldtian position, tracing it in fact back to Descartes. In Cartesian Linguistics, he sets forth Descartes' insights about language, and his conclusion that

> man has unique abilities that cannot be accounted for on purely mechanistic grounds, although, to a very large extent, a mechanistic explanation can be provided for human bodily function and behavior. The essential difference between man and animal

> is exhibited most clearly by human language, in particular, by man's ability to form new statements which express new thoughts and which are appropriate to new situations.[17]

Descartes considered the possibility of a machine which would give a specific number of responses to a specific number of cues, but pointed out that one could not conceive of a machine that could reply appropriately to everything said to it, as every human being can. However imperfect a man is, he can arrange words together to express his thoughts: however perfect an animal, it cannot. The distinction is basic and not just connected with peripheral organs, for a parrot can utter words, but cannot speak; a deaf mute cannot produce words, but can use language. Consider the parrot for a moment. We can easily train him to produce a number of sets of sounds that seem like utterances. With more care and appropriate use of reinforcement, we can train him to produce each of these 'utterances'on appropriate cues. There should be no difficulty in training the bird to utter sounds that seem like "Please feed me" in order to receive food, or like "It's a pellet of food" when the food appears from the hopper. By the definitions of behavioral psychology these utterances could be classified as a mand and a tact respectively, essential elements of what Skinner calls verbal behavior.[18] But I do not think that many of us would be prepared to call such behavior language. What is missing is the creative element: the parrot's repertoire of utterances remains

limited and closed: we do not find it one day saying "Please give me a pellet" unless it has been exposed to that particular sentence.

And the central fact in support of the creative aspect is that humans produce (and of course understand) many sentences that they have never heard before. For the parrot to learn English by memorizing all the sentences of English would be a clearly impossible task, for there are about 10^{30} possible English sentences of twenty words or fewer (by comparison, there are about 3×10^{9} seconds in a hundred years). This creativity is the basic distinction between what I have called language-like behavior and knowing a language.[19] While precise specification may not be possible, for there is a continuum, the interpretation of each is relatively clear. Thus, language-like behavior refers to the parrot trained to speak, and equally well to the student who is able to recite a number of sentences in a second language but not to modify them and use them in a free conversational situation. This example of the students learning a second language makes the continuum clear, for there is a stage at which the student may be able to use his stock of sentences to answer a finite set of questions.

But this is not the same as knowing a language, which involves the ability to produce an indefinite number of sentences in response to an indefinite number of stimuli. One is said to know a second language when one's competence is like that of a native speaker. Performance need not however be identical, for it is accepted that someone knows a language even when he speaks hesitantly, with many errors, or with a foreign accent, or when he understands it with some difficulty under conditions of noise. What confuses the distinction between language like behavior and knowing a second language is a third category, speaking a second language with the grammar of the first. It is thus normal for a person who knows one language and has developed language-like behavior in a second to be able to adjust this behavior in accordance with the grammar of his first language. It is this that differentiates the human language learner from the parrot. Again, it is a matter of degree, but we would not normally want to say that such a person has learned a language until he has developed linguistic competence in it, and until he is able to understand and create novel sentences in it according to its grammar and not just to the grammar of his first language.[20]

The creative aspect of language is one of the cornerstones of the argument for transformational grammar, for only such a grammar has available the "technical devices for expressing a system of recursive process," and only with such devices can the creative aspect be formulated explicitly.[21] The only

way to handle the fact that language has an infinite set of sentences and that is used by people with a finite time for learning is to postulate a system of rules. The task of the grammarian is to find the best statement of the form of these rules. Knowing a language is a matter of having mastered these (as yet incompletely specified) rules; the ability to handle new sentences is evidence of knowing the rules that are needed to generate them.

It is important at this juncture that we make a clear distinction between two pairs of terms that are often confused, competence and performance, and comprehension and production. The following passage discusses competence and performance.

> The speaker produces a signal with a certain intended meaning; the hearer receives a signal and attempts to determine what was said and what was intended. The performance of the speaker or hearer is a complex matter that involves many factors. One fundamental factor involved in the speaker-hearer's performance is his knowledge of the grammar that determines an intrinsic connection of sound and meaning for each sentence. We refer to this knowledge - for the most part, obviously, unconscious knowledge - as the speaker-hearer's "competence." Competence, in this sense, is not to be confused with performance. Performance, that is, what the speaker-hearer actually does, is based not only on his knowledge of the language, but on many other factors

> as well - factors such as memory restrictions, inattention, distraction, nonlinguistic knowledge and beliefs, and so on. We may, if we like, think of the study of competence as the study of the potential performance of an idealized speaker-hearer who is unaffected by such grammatically irrelevant factors.[22]

The grammar of a language, then, is a description of competence; it may be compared, to use an analogy first suggested by Saussure, to the score of a musical work. The score necessarily underlies any performance, but does not account for all the features of any single performance. A moment's thought makes clear that linguistic performance may be either active or passive, that both the speaker and the hearer are in fact performing. The implication of this for language learning is extremely important, for it suggests that one may learn a language just as well by listening as by speaking. The implication for language testing is equally important, for it suggests that we can find out about 'knowledge of a language,' which is the same as underlying linguistic competence, equally well when we test passive and active skills.

This last does not of course mean that an individual's performance as a speaker is the same as his performance as a listener; such a claim would clearly be ridiculous, for it would be tantamount to saying that anyone who could read a Shakespeare play could also write it. All that it does

claim is that the same linguistic competence, the same knowledge of rules, underlies, both kinds of performance.

Knowledge of rules is also the principal factor in the understanding of messages with reduced redundancy. Miller and Isard (1963) have shown that the intelligibility of a sentence depends on it following syntanctic and semantic rules. Sentences which break semantic constraints (e.g., "A witness appraised the shocking company dragon") prove more difficult to understand and repeat than those that do not, and ungrammatical sentences (e.g., "A diamond shocking the prevented dragon witness") prove even more difficult. This effect became even clearer when they studied the resistance of sentences to masking by added noise; grammatical sentences proved to be far more resistant than ungrammatical ones. Thus, they showed that the "knowledge of the language" providing the listener with help in handling sentences with reduced redundancy was a knowledge of rules, of the grammar of the language.[23]

If we accept that "knowledge of a language," "linguistic competence," is a matter of knowledge of rules, what implications does this have for language testing? First, we must keep clear the various reasons for which language tests are designed; we are concerned here with proficiency tests, or what Lewis has called "summative assessment"[24] and not with diagnostic tests. Further, we are concerned with a test that is independent of a specific set of materials and of the language analysis that lies behind it. In searching for a test of overall proficiency, then, we must try to find some way to get beyond the limitation of testing a sample

of surface features, and seek rather to tap underlying linguistic competence. This can only be done with any degree of certainty if we can be sure that we are presenting the subject with novel utterances, or calling on him to produce utterances that he had not heard before. The simplest way to do this is to set up an interview situation calling for normal language functioning; this method however is both difficult to score reliably and prohibitively expensive to administer. A long term solution to this problem is to use such interviewing techniques as a method of validating other measures.[26] Until this is done, another worthwhile approach appears to be to make use of the principle of redundancy and test a subject's ability to function with a second language when noise is added or when portions of a text are masked.

At last year's conference, I reported on the test of overall proficiency which we devised based on this approach. In the meantime, we have prepared a multiple-choice version of the test. The distractors were written on the basis of the more common errors made in the administration of the test as a dictation test. The results of the multiple choice test look as good as those we got with the dictation form, and the new format has made item analysis much easier.

Notes

1. Fries (1945), p. 3.
2. Loc. cit.
3. The words 'more or less' are used advisedly, for there is a real sense in which the lexicon of a language is open set; new words (and meanings) are being added and old ones dropped all the time. But at any given time, the words of a language are listable, in a way that the sentences of a language cannot conceivably be.
4. One particular type of sampling that has been proposed is to test only those items or combinations that do not occur in the subject's native language. See Lado (1961). For counter-arguments, see Upshur (1962).
5. Fries (1945), p. 33.
6. See for example the appendix to Fries (1945).
7. A detailed examination of the nature of language tests that follow from these principles is given in Lado (1961). While he does discuss various types of tests of the 'integrated skills', he spends more than twice as much space of specifications for tests of the 'elements of language': the sound segments, stress, intonation, and grammatical structures (which he defines as "the patterns of arrangement of words in sentences and the patterns of arrangement of parts of words in words").
8. The point of this example is that you have to know some physics as well as some English to understand such a lecture; in fact, the more physics one knows, the less English one needs.

9. In the terms proposed by Carroll (1961), to list the discrete points that make up the overall ability.
10. See Spolsky (1968).
11. See Shannon and Weaver (1949).
12. The exact value is of course different, for the number of first names starting with each letter varies.
13. Spolsky et al. (1968).
14. Chomsky (1964), p. 56.
15. Quoted by Chomsky (1964), p. 59.
16. Godel (1966), p. 492.
17. Chomsky (1966), p. 3.
18. Skinner (1957).
19. Spolsky (1966).
20. Lado's suggestion that contrastive analysis precede language testing is a recognition of this problem.
21. Chomsky (1965), p. 8.
22. Chomsky and Halle (1968), p. 3.
23. An alternative explanation in terms of a Markovian model is possible, but has been shown to be inadequate on other grounds. See Chomsky (1956).
24. Lewis (1968).
25. The lack of such a test invalidates most attempts to compare the effectiveness of various teaching materials, for the selection of specific language elements for the test will bias it in favor of the materials using the most similar selection.
26. See Spolsky (1968).

References

Carroll, John. Testing. Center for Applied Linguistics, 1961.

Chomsky, Noam. Current Issues in Linguistic theory, in The Structure of Language, edited by Jerry A. Fodor and Jerrold J. Katz. Englewood Cliffs; Prentice-Hall, 1964.

_____. Aspects of the theory of syntax. Cambridge, Mass.: MIT Press, 1965.

_____ and Halle, Morris. The Sound pattern of English, New York: Harper and Row, 1968.

Fries, Charles C. Teaching and learning English as a second language, Michigan: University Press, 1945.

Godel, Robert. F. de Saussure's theory of language, in Current Trends in Linguistics, Volume III, edited by Thomas A. Sebeok. The Hague: Mouton & Co., 1966.

Lado, Robert. Language Testing. London: Longmans, 1961.

Lewis, E. Glyn. International education assessment: English as a foreign language. Problems in Foreign Language Testing, Language Learning, Special Issue Number 3, 1968, 125-45.

Shannon, Claude E. and Weaver, Warren. The mathematical theory of communication. Urbana: University of Illinois Press, 1949 (1963).

Skinner, B. F., Verbal Behavior. New York: Appleton-Century-Crofts, 1957.

Spolsky, Bernard. A psycholinguistic critique of programmed foreign language insturction. International Review of Applied Linguistics 4 (1962) 487-96.

_____. Language testing - the problem of validation. TESOL Quarterly 2 (1968) 88-94.

_____. Sigurd, Bengt; Sato, Mashito; Walker, Edward; Arterburn, Catherine. Preliminary studies in the development of techniques for testing overall second language proficiency. Problems in Foreign Language Testing, Language Learning, Special Issue Number 3, 1968, 79-101.

Upshur, John. Language proficiency testing and the contrastive analysis dilemma. Language Learning 12 (1962) 123-8.